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F-22 Strategic Risk: A Retrospective Look with Future Implications

by

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United States Army War College
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F-22 STRATEGIC RISK: A RETROSPECTIVE LOOK WITH FUTURE IMPLICATIONS

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F-22 STRATEGIC RISK: A RETROSPECTIVE LOOK WITH FUTURE IMPLICATIONS

> DoD balances resources and risk … [based on] the *capabilities* our Armed Forces need [and] the aggregate *capacity* required to accomplish missions.
>
> —2010 Quadrennial Defense Review[1]

The purpose of the Department of Defense (DoD) is to defend and advance the interests of the United States and to provide military forces to ensure the nation's security.[2] The 2010 Quadrennial Defense Review (QDR) asserts it is critical to balance resources and risk now and in the future to achieve DoD's priority objectives: "prevail in today's wars, prevent and deter conflict, prepare to defeat adversaries and succeed in a wide range of contingencies, and preserve and enhance the All-Volunteer Force."[3] DoD faces difficult decisions every year in budgeting despite that in 2010 the US Defense budget exceeded $693 billion, over 60 percent of the total spent by the 10 countries that allocate the most for defense.[4] There are not enough funds to fulfill all the Department's needs to meet the National Military Objectives of "counter violent extremism, deter and defeat aggression, strengthen international and regional security, and shape the future force" with minimum cost, schedule, performance, personnel, and operational risk.[5]

One of the choices made as part of the Fiscal Year (FY) 2010 budget and the 2010 QDR was to end the production of the Air Force's F-22 fighter at 187 airplanes instead of procuring the Air Force's requirement of 381 airplanes.[6] This paper provides a retrospective look at the F-22's background and several risk categories DoD and the Air Force considered and ultimately accepted during these deliberations. Further, it surmises what the compounded risks are today as the 2013 and beyond budgets are declining, F-35 deliveries are delayed, and the security environment evolves.

Defense Department Budgeting Process Overview

In DoD, budgetary decisions are complicated. The Planning, Programming, Budgeting, and Execution (PPBE) system, initially instituted by Secretary of Defense Robert McNamara in the 1960s, is the foundation of the DoD strategic and budgetary decision making processes. It provides strategic guidance, long-term phasing of programs for all the services, budgeting to meet personnel, construction, research and development, procurement, sustainment, and operations and support needs, and a mechanism for tracking expenditures. Each service implements PPBE to provide its recommended annual and long-term budget to the Office of the Secretary of Defense (OSD) staff. OSD ensures services meet the intent of the Defense Planning Guidance and the fiscal realities of the budget, and then combines the service and defense agency budgets into the DoD budget. The annual DoD budget is provided to the Office of Budget and Management which consolidates all the Cabinet department budgets into the President's Budget, which is submitted to Congress the first week of February. DoD's process to develop the Future Years Defense Program (FYDP), the five year rolling budgetary outlook, takes about a year and a half from gathering inputs to the actual submission of the President's Budget each year. The FY12 base budget was approved at $530.6 billion and the requested budget for FY13 is $525.4 billion, both excluding Overseas Contingency Operations (OCO) supplemental funds.[7]

The main thing PPBE does not provide is a clear prioritization of programs between services. The only clarity that emerges is if a program is in the budget, it is de facto more important than one cut from or not included in the budget. Services have many top priorities in order to meet their prescribed roles and missions. For instance, the Air Force's twelve core functions as described in Air Force doctrine are: Nuclear

Deterrence Operations; Air Superiority; Space Superiority; Cyberspace Superiority; Command and Control; Global Integrated ISR; Global Precision Attack; Special Operations; Rapid Global Mobility; Personnel Recovery; Agile Combat Support; and Building Partnerships.[8] Therefore programs that are clearly tied to those areas, and preferably multiple functions, have a higher likelihood of making the Air Force's cut line.

Even in the recent years when the defense budget was at its highest and wartime supplemental bills augmented the coffers of the defense department while fighting two wars, the services did not have enough funding to meet all their requirements, much less their "desirements." So the services are always forced to make difficult choices in order to balance between research and development of new capabilities and platforms, modification of existing platforms for additional capability and service life, procurement of new systems, sustainment, military construction, and operations costs such as personnel, fuel, and training. Plus, for the different capabilities – for example tactical airplanes, mobility aircraft, space and satellites, weapons, and enabling capabilities like datalinks – the corporate structure must determine how much of each requirement will be funded. Deciding what to recapitalize, sustain, retire, and initiate is a complex decision process wherein the personnel, acquisition, requirements, and programming communities must eventually come to a consensus on how to fulfill the war plans of the combatant commanders (CCDRs). As part of this process, the leadership must also determine where strategic, operational, and tactical risks can be taken with the minimum impact to achieving national objectives because not all efforts can be funded. Finally, each service makes all these decisions in order to remain within its Total Obligation Authority, that is, its share of the DoD budget to accomplish its roles.

One mission set exclusively held by the Air Force is to provide and ensure a theater-wide air superiority capability. Because of its air dominance, America has not lost a single soldier or Marine in combat due to a threat from the air in well over 50 years.[9] The F-15C Eagle has been the primary platform accomplishing this mission since the mid 1970s. F-15Cs can penetrate enemy defenses and can "outperform and outfight any current enemy aircraft."[10] The Air Force started development on the next air superiority platform in 1986 to counter growing Soviet threats with the expectation that F-15C would exceed its service life (measured in hours); this new program eventually became the F-22. Also, after Desert Storm, then Chief of Staff Merrill McPeak announced that the Air Force would never buy a non-stealthy fighter again.[11] Although many F-15Cs are still in service, the Air Force has now fielded the most advanced fighter aircraft in the world which is designed to counter more hostile environments and replace some aging F-15Cs. This airplane is the F-22A Raptor.

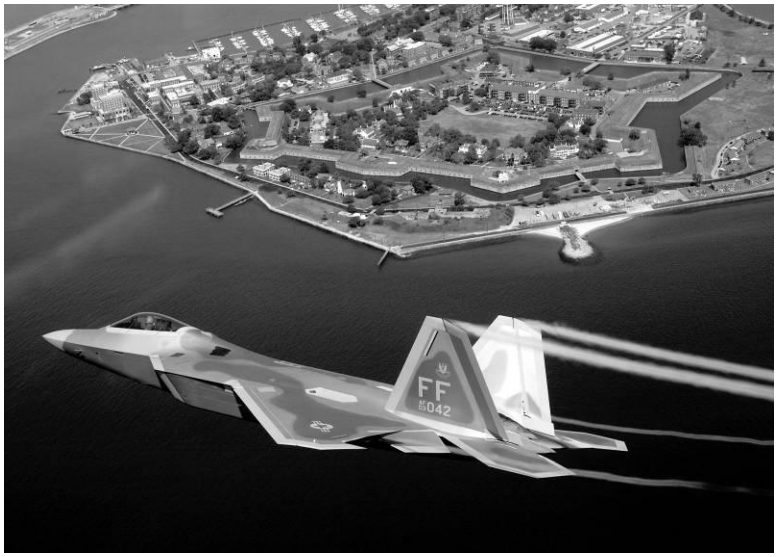

Figure 1: F-22 over Fort Monroe, Virginia (Air Force Photo by Tech Sgt Ben Bloker)[12]

F-22A Raptor Overview and Program History

The F-22 is the world's preeminent fighter airplane. The Raptor "is designed to project air dominance, rapidly and at great distances and defeat threats attempting to deny access to our nation's Air Force, Army, Navy and Marine Corps. The F-22 cannot be matched by any known or projected fighter aircraft."[13] The F-22 is the first fifth-generation fighter, and combines air-to-air and air-to-ground capabilities with sophisticated stealth, supercruise, maneuverability, and integrated avionics which yield increased survivability and lethality over its predecessors and adversaries.

The F-22 began as the Advanced Tactical Fighter. The program entered the Demonstration/Validation phase in 1986 and began the Engineering, Manufacturing, and Development (EMD) phase of the acquisition lifecycle in 1991.[14] The program encountered many challenges throughout its development because of the tremendous technology leaps being included, such as integrated avionics and stealth technology, and the program progressed slower than originally planned. Delays in program development translated to cost increases, which frequently hampered the progress of the F-22 program. Politically, some in Congress also questioned the management of the program, justifications for cost increases, and the fundamental need for the system. The F-22 has often been a polarizing concept and weapon system in political and media circles. Fans extol the values of the high technology and unmatched capability while detractors decry the lack of a requirement without a Cold War foe or a true air superiority peer and costs and delays which were perceived as unacceptable.

The F-22 began Full Rate Production and achieved Initial Operational Capability in 2005, and Full Operational Capability was declared in December 2007. However, the F-22 was not used in Operation Iraqi Freedom (OIF) or Operation Enduring Freedom

(OEF); there was no need for an air superiority aircraft with this extreme capability given the lack of robust enemy air defenses and the lack of an opposing Air Force or air-to-air threat in those theaters. Also, the Air Force was just coming up the learning curve in terms of deployments, basing, and training, so despite being "operationally capable," the entire system was not ready for sustained combat operations in time to make a difference in the earlier phases of OIF or OEF. Moreover, it is not the right aircraft for constant close air support engagements as seen in today's war efforts; there are other platforms which are better equipped to directly support ground warfighters, such as the F-15E, F-16, and B-1, which have more air-to-ground weapons and the targeting pods needed to meet the theater rules of engagement. Despite the lack of usage in OIF or OEF, it does have a critical role in meeting national military objectives against more credible air threats. F-22 is first and foremost designed for air superiority, although it has an air-to-ground capability as it carries two 1000-lb Joint Direct Attack Munitions (GBU-32) and will be able to employ eight 250-lb class Small Diameter Bomb I weapons (GBU-39/B) at subsonic or supersonic speeds once Increment 3.1 is fielded.[15] F-22 represents a vital capability for deterring enemies and for ensuring success in robust tactical air engagement, essential for the joint force of today and the future.

When the F-22 program entered EMD in 1991, the Air Force was approved to procure up to 650 airplanes; by 1997's QDR, the quantity was reduced to 339 and in 2003, due to an OSD budget cap, the number declined to 277.[16] At the same time, several studies were conducted inside and outside the government, and many came to the conclusion that 381 was the optimum number of F-22s for the Air Force to meet its mission requirements.[17] Eventually, in December 2004, Program Budget Decision

(PBD) 753 reduced the quantity to 179.[18] Several years of debate and attempts to add additional F-22s back into the budget followed, but eventually the Secretary of Defense and the President decided to terminate F-22 production. Finally, the 2010 QDR and the FY11 President's Budget announced the end of the F-22 production program, although the Air Force was allowed to buy a grand total of 187 F-22 jets to account for other aircraft losses in OIF and OEF with savings reaped from a multi-year procurement program and additional OCO funds.[19] The inventory of 187 included 6 Production Representative Test Vehicle II aircraft, 179 production aircraft, and 2 previously procured EMD aircraft funded via RDT&E funds.[20]

As with most production programs, F-22 production became more efficient as the processes stabilized. Lockheed-Martin successfully delivered F-22s on time for more than 5 years.[21] The final production F-22 Raptor rolled off the production line on 13 December 2011, bringing the total inventory to 185 aircraft, 2 less than the program of record of 187 due to F-22 aircraft lost in accidents.[22]

F-22's cost, as with any other program, depends on the elements used to compute it; therefore, it is important to understand what is involved and to ensure the same types of costs are used when comparisons are made. The most encompassing category is life cycle cost which includes research and development, procurement of the main system, support equipment, spares, operations and support, military construction, and disposal. One of the easiest cost categories to make comparisons with is flyaway cost. Flyaway cost refers to the cost of procuring just the prime mission equipment (e.g., an aircraft).[23] F-22's flyaway cost in 2009 was about $143 million; the budget documentation submitted to Congress shows the average flyaway cost for the 179

production planes was about $152.5 million.[24] As with most programs, flyaway costs steadily declined as the contractor became more efficient in production; this trend would have continued if production were not halted early. As a metric to compare cost (using FY10 then year dollar calculations), the flyaway cost of each F-22 is about 4 to 6 times greater than an F-15 or F-16.[25] Furthermore, the total F-22 program cost is over $66 billion, significantly higher than originally budgeted.[26] With the exception of F-35, F-22 is the most costly fighter aircraft program in history.[27]

Why was the F-22 Cancelled?

Extensive commentary exists surmising why the F-22 program was terminated early. Some of the requirements-based reasons include: the perception that it was a Cold War era weapon not needed in the modern battle with no near peer; some performance requirements which became obsolete were still levied on the program and were more stringent than necessary; the belief that the F-35 Joint Strike Fighter would offset fewer F-22s at a much lower cost; and political opposition trumped the military's divided opinions of the risks. Some insurmountable acquisition process criticisms were: significant numbers of costly modifications required immediately after fielding due to obsolescence; modernization programs to provide previously planned capability were not well received; the program's structure often gave the contractor more leverage than the government during contract negotiations when programmatic risk was higher; taking more than 19 years from the beginning of development until initial operational capability; and escalating program costs despite control measures being in place. Further, non-evolutionary acquisition practices, which were common when the program started, were outdated by the time the system fielded; an earlier evolutionary acquisition strategy could have helped relieve some of the demands on the program. Also, the program

office and the contractor underestimated the technological and political challenges they undertook. Plus, new and highly advanced technology is not easy to develop, integrate, or field. Ultimately, all the reasons listed above contributed to F-22's cancellation.

Secretary Gates, who ultimately convinced the President and Congress to truncate F-22 production, indicated several reasons why he advocated for this change. First, he believed it was important to reorient the US military to winning unconventional conflicts instead of fighting major powers. He went on to say that the decision to end F-22 production (and C-17 production and restructure Future Combat Systems and other large changes) was "one of those rare chances to match virtue to necessity; to critically and ruthlessly separate appetites from real requirements."[28] Also, he asserted that politics played no role in his analysis. He clearly believed that investments in other technologies such as F-35, unmanned aerial vehicles, intelligence, surveillance, and reconnaissance platforms as well as special operations forces were more vital to the meeting the challenges of the strategic environment while posturing the US military to defend its national interests around the world today and tomorrow and minimizing risk.

Risk in the Quadrennial Defense Review

Analyzing strategic risk is a complicated proposition for several reasons. First, strategic risks are not easily quantified, so the assessments are more qualitative; also, the time horizons in question are typically longer than for operational risks. Next, strategic risks tend to involve assessments of the unknown. Strategic risks must be viewed from many perspectives, including technical, political, fiscal, diplomatic, and perception of success. These salient points highlight the difficulty in properly identifying and categorizing risk, as well as the importance of continuing to relook assumptions as time progresses to see what in the environment may have changed. Strategic risks

tend to balance risk and reward, so they are also called “compensated” risks because taking the risk is “often inseparable from the enterprise’s strategy.”[29] For defense, the decision to pursue or not to pursue one program over another definitely hinges on balancing risks with priorities and national strategy.

The 2010 QDR implemented a multidisciplinary, strategy-driven risk assessment approach to address how the DoD should manage risk. Four risk categories employed since 2001 were used as the framework to organize this near, mid, and long term look across the Department: operational; force management; institutional; and future challenges risks. Each of these risk perspectives will be examined in greater detail.

Operational Risk. The first area to consider is operational risk, “the ability of the current force to execute strategy successfully within acceptable human, materiel, financial, and strategic costs … [including] the Department’s ability to execute current, planned, and contingency operations in the near term.”[30] The first step in determining operational risk is to review the CCDRs’ Operational Plans (OPLANs) to assess requirements and strategic assumptions for various scenarios. Next, the total number of forces to fulfill the planning guidance and national strategy needs to be calculated and gaps equating to risk identified. The department then decides to accept the risk or plan how to mitigate it. When the QDR was written, DoD’s espoused strategy was to win today’s wars, be able to counter aggressions from two nation-states simultaneously and to cope with homeland defense, humanitarian crises, and natural disasters.[31]

Air Combat Command (ACC) expressed serious concerns during this timeframe with the operational risk of F-22 quantities less than 381, the Air Force’s articulated requirement. The Air Force never planned to have a large number of F-22s, but through

many different studies, 381 F-22s was determined to be the "optimum number in which cost, schedule, and warfighting risk become balanced and meet basic Strategic Planning Guidance (SPG) guidance criteria of swiftly defeating two overlapping campaigns."[32] An important caveat to this number is that these studies often assumed maintaining a low operational risk level and a fiscally unconstrained environment; these assumptions are not necessarily realistic when budgetary pressures are higher and have greater than usual influence on decision making. 381 F-22s were deemed adequate to cover 76 percent of the CCDRs' requirements, which would equate to 240 Primary Mission Aircraft Inventory (PMAI) jets, i.e., combat coded and ready to go to war, as well an adequate number for Backup Aircraft Inventory, Primary Training Aircraft Inventory, Primary Development/Test Aircraft Inventory and Attrition Reserve aircraft.[33]

As a whole, OSD and Congress did not accept the Air Force's strategic rationale for 381 F-22s or the cost of the program, and as discussed earlier gradually decremented the program to 179. 179 jets created a significant operational risk; estimates indicated only 29 percent of SPG requirements could be met, which was deemed an unacceptable level of risk by the Air Force operations and requirements communities because "the nation is accepting an increased risk in terms of time and attrition to accomplish the objectives outlined by the National Defense Strategy."[34] To counteract this risk, in 2008 the Air Force tried to negotiate with OSD for an intermediate number of 268 airplanes. This increased number would cover about 53 percent of the CCDRs' requirements but was believed to be a more acceptable level of risk because it could cover the two most stressing scenarios and was fiscally constrained. Additionally, the Air Force advocated that increasing the inventory

"provides a good compromise on future force structures mix, resolves sufficiency concerns, and eliminates the industrial base fighter production gap until the F-35 can enter Full Rate Production."[35] This attempt to reduce risk did not trump the affordability argument in the budget process, and the result was the final 187 aircraft program.

The Air Force took several approaches to mitigate the operational risk of fewer F-22s. The first was to look at the defense strategy. In order for the Air Force to agree there were enough F-22s to meet the prescribed mission sets, the prevailing wisdom was the Air Force would plan for one major theater wide conflict and absorb the risk of whatever scenarios would arise simultaneously instead of planning to be fully engaged in multiple major conflicts at the same time. At the time, the Air Force planned to present forces to the CCDRs in 10 Air Expeditionary Force "buckets." 240 PMAI aircraft equated to one F-22 squadron being assigned to each bucket, so there would always be F-22s ready to meet CCDRs' needs. 187 aircraft does not allow this rotation since it equates to roughly 120 PMAI, half the number the Air Force insisted was required.[36] Fewer planned airplanes drove F-22s to be viewed as a lower density asset, potentially to be tasked as more of an emergency response force instead of a planned force.

Another step to mitigate risk for the CCDRs was to determine how much additional legacy fighter quantity and capability would have to be maintained or enhanced to partly compensate for the reduced number of F-22s. Some overlap in the legacy and fifth-generation fighters was always planned to meet worldwide air superiority needs, but delays in the F-22 development and reduction to the planned procurement numbers caused the Air Force to accelerate retirements of some its oldest fighters in order to afford needed capability upgrade programs and service life extension

programs on others. The number of F-15 Eagles (A/B/C/D models combined) still in the inventory as of October 2009 was 522, about half of the total ever produced.[37]

In order to have any chance of staying relevant, service life extension programs (SLEP) and modernization efforts are essential to ensure legacy fighters remain viable. The Air Force plans to have about 176 "Golden Eagle" F-15Cs projected to be used until 2030.[38] These jets are being upgraded with new capabilities, most importantly a new active electrically scanned array (AESA) radar to improve the F-15C's ability to detect, identify, and attack threats at greater distances.[39] The "Golden Eagles" will help fill the gap of F-22s by meeting about 50 percent of the worldwide air dominance requirements which alleviates a good portion of the operational risk, but F-15Cs cannot be used in the most severe threat environments without significant risk of loss.[40] Golden Eagles are more robust and modern than the legacy F-15Cs and have an advantage of carrying more fuel than F-22s, but they lack F-22's stealth, supercruise, and maneuverability.

The biggest problem with solving operational risk by upgrading older aircraft is that the fleet still continues to age and becomes more expensive to operate. Fiscal savings from buying less F-22s must be diverted into these modernization programs and they are also funneled into paying for the higher operations and sustainment costs for the legacy airplanes, so the expected savings from reducing F-22s do not fully materialize. The net result is that DoD ends up with a less capable, less modern force for the same or more cost with more risk of being able to achieve all of the mission sets. The same problem is being seen with F-16 as it undergoes numerous SLEP efforts while waiting for F-35 production to ramp up. Again, these funds are being diverted

from acquisition of more modern aircraft and incurring the substantial sustainment bills for upgrading and maintaining legacy aircraft.

Acquisition professionals traditionally define risk in terms of probability and consequence of an event that has not yet occurred. Some view the operational risk for fewer F-22s to be low since it has not been used in combat because of unchallenged US air superiority, and that the probability of being employed in the future is low because some see conflict in the Asia-Pacific theater as so highly unlikely. This perspective is based on the US and China being engaged in economic or information battles; the interdependence of these globalized economies makes military conflict seem less likely. A less optimistic view is that the probability of conflict with a near-peer or peer requiring F-22's level of air superiority is low, but the consequence of not having adequate F-22s if those OPLANs were activated is catastrophic to the nation's ability to seize the initiative and conduct the desired numbers of offensive operations in anti-access/anti-denial environments. Also, "while the risk of conflict with China cannot be ignored, neither should it be exaggerated."[41] Other conflicts are much more likely and not predicted, such as our involvement in the Balkans, Afghanistan, Iraq in 2003, and more recently Libya. Ultimately, the operational risk of the decision to reduce the number of F-22s depends on worldview. If the prevailing belief is that the US is more likely to be involved in non-peer conflict, then the perceived operational risk is lower because the force is reasonably balanced for a wide array of enemies. If concerns about the rise of other nations with increasing sophistication of air-to-air and particularly ground-to-air threats dominate thinking, then operational risk causes more angst despite the complementary systems the US joint force has to counter potential enemies.

Force Management Risk. The second category is force management risk, the "ability to recruit, retain, train, educate, and equip the All-Volunteer Force, and to sustain its readiness and morale … in the near term, midterm, and long term."[42] The Air Force Recruiting Service "recruits the brightest candidates possible, and then provides them with tough, highly technical training that gives them the right skills to sustain the combat capability of America's Air Force."[43] Culturally, the Air Force prides itself on operating high technology platforms to achieve its missions, whether they are airplanes, satellites, or remotely piloted aircraft and it recruits accordingly.[44] Over the past 12 years, the Air Force has consistently exceeded its annual goals.[45] Officer and enlisted retention is also high, so much so that the Air Force was compelled to institute voluntary and non-voluntary force reduction measures to decrement the size of the force over the last few years. "Air Force retention is at a 16-year high and active duty end strength remains bloated above congressionally mandated levels;" the Air Force is taking steps to be at the active duty authorized end strength of 332,800 by the end of Fiscal 2012 and has announced plans to reduce an additional 9,900 active, reserve, and guard airmen.[46]

Americans join the military for many reasons such as to serve their country, to get an education, and to make a difference in the world. People stay in the military for many reasons as well, including earning a retirement pension, assuring job stability when the civilian job market is depressed, working beside great people, taking advantage of unique opportunities, and continuing to defend the nation. Given the recruiting and retention statistics, the Air Force is apparently meeting its members' expectations, which are also buoyed by a difficult economy. However, the number of F-22s is not a contributing risk factor to recruiting and retention holistically.

However, only 187 F-22s drives unexpected implications to force structure and training. In 2004 General Hal Hornburg, the ACC commander, stated, “We can do with fewer [new airplanes than legacy airplanes] … we have airplanes now emerging that are so much more capable that F-15 and F-16 that we believe replacing them one-for-one is not required.”[47] F-22 squadrons often have only 18 to 21 Primary Aircraft Assigned (PAA) compared to 24 PAA for legacy fighter squadrons.[48] From a pilot manpower perspective, this number and current policy dictate the aircrew ratio. The number of planes also drives the calculus on the number of flying hours available for the unit during each year. As a squadron commander, it is challenging to keep all of the pilots current with a reduced number of primary and backup aircraft, especially when the average mission capable rate hovers around 60 percent, even though the rates continue to improve.[49] Flying T-38s and simulators help to with maintain basic airmanship skills, but they cannot replicate all the skills an F-22 pilot needs to rehearse. The F-22 community also sustains its proficiency by participating in realistic combat training exercises around the world. These exercises benefit morale because the pilots continue to hone their combat skills despite not being actively engaged in combat.[50]

The PAA number also generates the size of the authorized maintenance personnel cadre. There are clearly challenges with keeping a proficient military maintenance capability when there are so few F-22 bases and so few other low-observable aircraft in the Air Force inventory. Additionally, even an experienced enlisted fighter maintenance professional may not immediately possess the necessary skills to maintain F-22s when transitioning from a legacy weapon system, even though they hold all the qualifications on paper.[51] And of course, the Air Force expects its

personnel to rotate to other bases instead of “homesteading” which is beneficial for spreading new ideas and developing airmen but can be detrimental to building a core of people who are experts in a specialized skill set. Early on, fluctuating personnel proficiency compounded by a smaller inventory of F-22s contributed to lower than desired mission capable rates, but proficiency and availability continue to increase.

Finally, the challenge with educating and training the pilot force is that the lack of airplanes overall slows the pipeline for introductory training at Tyndall Air Force Base, upgrade training at home station, and advanced training at the Weapons Instructor Course at Nellis Air Force Base. Further, there are fewer sorties available for the most experienced F-22 pilots to test software and weapon system upgrades as well as to develop tactics, techniques, and procedures to be disseminated to the field since those jets at Nellis are shared with the Weapons Instructor Course.[52] This reduction in innovation from the users also hampers the acquisition community’s ability to try to implement programs to upgrade capabilities or reverse deficiencies discovered in realistic scenarios because the overall process is slower.

Overall, the risk incurred by the Air Force in the force management realm should be categorized as low to medium. The impact of fewer airplanes is evident in the slow pace of test and training opportunities. From an operations and maintenance manning perspective, F-22 will suffer no more than any other platform. Degraded morale issues which may arise are more likely attributable to dissatisfaction with the Air Force-wide non-voluntary force shaping initiatives and the five months that the entire F-22 fleet was grounded during 2011 for issues with its oxygen system. The normal ebb and flow of F-22 operations, training, and manning are less likely to drive morale declines.

Institutional Risk. Third, institutional risk is "the capacity of management and business practices to plan for, enable, and support the execution of DoD missions … [and] develop effective and efficient organizations … over the near term, midterm, and long term."[53] One objective in the 2010 QDR was to "further reform the Department's institutions and processes to better support the urgent needs of the warfighter [and] buy weapons that are usable, affordable, and truly needed."[54] This section focuses on the defense acquisition system, the defense industrial base, and F-22's termination impact.

Despite its cost and schedule issues, F-22 experienced some notable acquisition successes which should be adopted in future programs. First and foremost, the industrial base and the U.S. government partnered to field an airplane that is unmatched. Also, once production got on track, F-22 had over five years of on time deliveries to the field. Additionally, production costs per airplane were declining appropriately. Finally, phasing the software into increments allowed F-22 to be fielded initially, with additional capability to come later by adding more mature technologies. This prevented creating a greater development chasm which would have further slowed fielding and caused angst in the acquisition oversight and user communities.

F-22 endured many valid criticisms from OSD, Congress, and the media as it proceeded from development through production. First, challenges in developing and integrating highly advanced avionics, stealth, and other critical technologies into a viable airframe caused the development program to be significantly slower than expected. Developmental schedule delays directly translate to program cost increases in design, redesign, and test as well as in the monthly burn rate which keeps the industry team working on the program. F-22's development cost was capped by law and revised

multiple times by Congress, but eventually ended up being over $30 billion. Second, it adopted an evolutionary strategy to incorporate additional technology, but it was very late in the program after it had already been under scrutiny for many years. It was a proper decision, but the program was not given credit for phasing the fielding for additional software, weapons integration, and extra radar capability given the overall delays and developmental timespan. Third, it was slow in meeting operational maintenance measures, such as mean time between failure. Readiness improved steadily once more airplanes were in the inventory and the maintenance personnel gained experience in low observable requirements, but the low metrics hurt the F-22's reputation as a system. Overall, the technical risk in the program was high, limiting the program's ability to achieve its objectives within its cost and schedule parameters. Dissatisfaction in OSD and Congress with slow, costly acquisition clearly factored in the decision and contributed to the demise of the program.

Unfavorable perception of one major defense acquisition program is a risk to other ongoing programs because of the effect on their reputations and their execution. Mistakes, poor execution of an acquisition strategy, and injects outside the program manager's control tend to cause additional policies and legislation to be created. Additional Congressional, OSD, and service oversight tends to ensue for other acquisition programs as well in an attempt to prevent a similar issue from surfacing in other programs. Since programs are often uniquely tailored, blanket policies and new processes are rarely helpful to provide revealing insights or to improve performance.

Improving acquisition performance processes to decrease institutional risk for all programs is important, even though it is too late for F-22 and probably for F-35 to make

enormous change. There is room for improvement in efficiency and effectiveness, so the probability of not being able to improve processes is low but the consequence of not improving acquisition is high for government, industry, warfighters, and the taxpayers.

Another area that could be examined for risk and reform is the requirements development process, which feeds the acquisition system. The QDR postulated "the requirements for new systems are too often set at the far limit of current technological boundaries … too often the result is disappointing initial performance followed by chronic cost and schedule overruns."[55] All stakeholders must become more sophisticated in their understanding of the requirements generation process, the determination of key performance parameters that the systems must meet, and the recognition of the cost and schedule impact of trying to maximize performance. The requirements process can be cumbersome and aims to maximize "possible" capability to meet warfighter gaps; rarely do users want to simply address what is "feasible" or "realistic" or "affordable" to meet their needs. This is one of the natural tensions in the acquisition system, but users need to understand that the elegant, higher technology system is often more fraught with risk. An evolutionary, phased program which deliberately grows capability is generally faster and more easily upgraded, often at a lower cost. One radical approach which has been proposed to alter the requirements system would be to change from a capabilities-based system where capability is generally more important than affordability to a threats-based requirement system which would help prioritize DoD investments based on realistic assessments of the most likely threats.[56] This was the requirements methodology used previously by DoD, but it would not be an easy endeavor to morph the system back. One key way to potentially

improve the threats-based process from its previous instantiation would be to require evolutionary acquisition to field capabilities incrementally, whereas the original system tended to field a “final” solution. This change could help mitigate risks of spending precious funds developing niche or overly capable weapons which address a very limited target set instead of focusing attention on programs which have great promise, address broader warfighter needs, and should have priority in the department. It could also help control operational test community’s weapon system tests beyond the scope of its specifications against threats the system may not be designed to defeat, as opposed to the defined threats. Understandably, threats can change over a lengthy acquisition program, but stable requirements engender more opportunities for success; upgrade programs can address adding new capabilities to meet the emerging threats without hampering the baseline programs and ensure the fielded system is effective.

According to the QDR, the sustainment of the defense industrial base is a vital subset of Institutional Risk.[57] The industrial base is complicated because it includes small and large companies, military and commercial focused entities, traditional and emerging technologies, as well as the organic capacity of the government. There are many differing concerns and variables between these different sectors of industry, and it is hard to define measures of merit that clarify the myriad of issues.[58] No longer do defense related technologies drive the market, so DoD is not in a position to dictate what investments private industry makes in technology development when the declining defense budget promises lower returns for industry. Regardless, the defense industrial base must exist and must be healthy in order for the nation to develop, procure, and maintain the capabilities it needs to achieve national security objectives.

Challenges facing fixed-wing development and production industries include the workload being insufficient to maintain existing workforce, an aging workforce, and military unique skills that cannot be maintained with the decreasing overall workload – all contribute to high risk for execution of new programs.[59] Design and development are the most manpower intensive phases in the acquisition life cycle and require the most technical and engineering experts. With a lack of new programs across the entire aerospace industry, it is becoming more and more difficult for industry to justify maintaining a "standing force" of personnel because that translates into overhead costs if there is no work to perform. It is not affordable for the government to support keeping industry expertise in large quantities either. Also, recreating a skilled production workforce is not easy when production ends. Highly skilled people find jobs elsewhere, so if they are needed again in the manufacturing plant at some point, they are most likely not available. It is difficult to recreate production facilities, such as floor space and tooling, once they have been liquidated. These problems are not exclusive to F-22.

Smaller businesses are often the first to be disrupted when decisions affecting large programs are made. Small businesses tend to be the third- and fourth-tier suppliers that generally get the bulk of their work by providing components and subcomponents in the advanced procurement. For F-22, production of each airplane took three years. Advanced procurement occurred in the first year of each aircraft's funding, so the last long lead item was probably delivered in 2009 or early 2010 to be included in the final F-22 delivered in December 2011. These smaller companies must find another buyer for their products, develop and market new products, or risk going out of business. But even first tier suppliers are at risk. "The Air Force in 2007

estimated that of about 1,000 first-tier F-22 supplier firms, roughly 110, or about 11%, were also F-35 suppliers [because of significant international participation], so most F-22 supplier firms would not be supported by F-35 production" if F-22 production were halted.[60] Impacts across the defense industrial base are not limited to the big prime contractors; in fact, they are harsher on the critical suppliers.

Studies released in 2009 declared, "Prematurely closing the F-22 line could jeopardize America's ability to hedge against potential miscalculations of the future threat environment."[61] But the decision was made, hence the risks are already assumed. Congress provided nearly $360 million across FY10-12 to complete procurement of equipment to stand up operational locations, complete deliveries of Lots 7-10 aircraft, and fund "production shutdown activities to preserve necessary assets for long-term fleet sustainment."[62] However, this implies that the program is not preserving all of the unique production tooling in case the government wished to restart production at some point, and is just keeping the tools that are needed for sustainment. RAND estimated that the cost to package the production tooling from the five locations which produced major subsections of the aircraft to be $17 million in non-recurring costs, and $150 thousand annually to maintain.[63] This would not have been a huge investment.

Further, costs to restart must also be examined. Restart costs would include planning and administration, tooling, personnel, and requalification of parts and processes.[64] RAND estimated that the cost to restart F-22, assuming a large time gap in production such as the current reality, would be at least $307 million. The cost for a notional number of 75 additional airplanes would be about at least $17.4 billion, which is $4.5 billion more than it would have been if 75 airplanes could have been tacked onto

the production line with no break in advanced procurement or production.[65] A decision to restart F-22 production in the future would have significant ripples through the Air Force and DoD budgets if it were determined more F-22s were the best solution to meet a critical national security need, but it is highly unlikely given the budgetary pressures.

There are multiple instances in the QDR and the new strategic guidance about the importance of sustaining the industrial base to mitigate risks for future acquisition, but there is not much evidence of action being taken or funding associated with the effort.[66] There is an office in the Under Secretary of Defense Acquisition, Technology & Logistics that is responsible for Manufacturing and Industrial Base Policy. It focuses on all aspects of the defense industrial base, large and small, and promotes "policies and actions that provide for long-term innovation, efficiency, profitability, and productivity growth."[67] It is challenging to discern whether its analyses of risks, interdependencies, and cost drivers actually translate into investments by DoD in shoring up deficiencies, creating new areas for industry to pursue, or increasing competition. It is difficult to find obvious funding lines dedicated to industrial base sustainment in the budget documentation in any meaningful amount. The concept of industrial base sustainment is acknowledged as good and necessary, but it is extremely difficult to implement because the link of funding to policy is second or third order at best and the government cannot afford to subsidize industry without a product to show for it. Further, industrial base support does not compete well in the budget against the pressing needs of today. Ultimately, the probability of not being able to sustain the industrial base is medium to high if more development and production programs are not initiated, and the consequence of not doing so is high.[68] The magnitude of the industrial base risk is not

solely attributable to F-22 cancellation as it already had a finite production plan and one program cannot singlehandedly sustain or cause the decline of the industrial base.

Future Challenges Risk. Finally, the fourth area is future challenges risk, "the Department's capacity to execute future missions successfully, and to hedge against shocks … [by fielding] superior capabilities and sufficient capacity to deter/defeat emerging threats in the mid and long term."[69] F-22 is clearly a superior capability but it is debatable whether it was procured in sufficient quantities to fulfill its role in multiple theaters simultaneously with varying threat levels. In 2008, Air Combat Command asserted that by only procuring 187 F-22s, "the nation is accepting an increased risk in terms of time and attrition to accomplish the objectives outlined by the National Defense Strategy."[70] Fortunately, F-22 has a fifth-generation complement, the F-35.

The F-35 Lightning II is a highly advanced multi-role fighter designed to defeat current and future threats. It is designed to replace many different legacy aircraft in the DoD inventory for the Air Force, Navy, and Marines. The program's procurement plan is 1,763 F-35A Air Force jets and a combination of 680 F-35B and F-35C aircraft for the Marine Corps and Navy.[71] All three F-35 variants are concurrently in development and low rate initial production, with the F-35A program farther ahead in testing. Initial operational capability for F-35A is planned sometime after 2016, with the other variants to follow.[72] Six F-35A and three F-35B aircraft have been delivered to date to Eglin Air Force Base, Florida, for pilot and maintainer training.[73] F-35's integrated capabilities represent another leap in technology, and the planned quantities will be able to address worldwide operational requirements in concert with F-22 and other platforms.

While F-22 aircraft, weapons, and sensors are optimized to seize and maintain air dominance, F-35's are optimized for Global Persistent Attack.[74] Both carry air-to-air and air-to-ground weapons and are stealthy, but they have design features precluding them from being completely fungible. They are not operationally interchangeable; they are complementary capabilities and both are needed to achieve national objectives.[75]

The risk posed to US forces by potential adversaries is that in fulfilling their own objectives, they continue to proliferate threats which severely diminish the combat effectiveness of US legacy aircraft and start to threaten sophisticated technologies. Instead of spending immense resources trying to design and build jets to match fifth-generation fighters, "many nations are following China's lead in putting more emphasis on anti-stealth, anti-access air defense technologies."[76] Also, "proliferation of modern surface-to-air missile systems by Russia and others will pose growing challenges for US military operations worldwide."[77] Modeling and simulation shows legacy aircraft are rendered nearly operationally obsolete until the threats are eliminated in robust scenarios. Fewer F-22s to clear the skies in the first attack wave may put even F-35s increasingly at risk in follow-on operations because legacy platforms cannot assist.[78]

In the most robust scenarios, the US is postured to address the threats. In the event that multiple theaters are facing combat operations, the highest threat theater would receive the preponderance of the fifth-generation assets and the less stressing scenario would employ the very capable legacy assets in the inventory to meet the CCDR requirements. This force structure best allows for preparedness and flexibility.

While waiting for F-35 to be fielded in the proper quantities to meet the CCDRs' needs, the DoD must mitigate the risk with SLEP programs on other platforms such as

F-16. Similar to the SLEP programs for F-15C previously discussed, F-16 is undergoing SLEP efforts particularly in structural enhancements because eventually aircraft structural elements will fail over time after repeated use in the intense speed and G-forces of the fighter environment.[79] Planes can either undergo modernization programs to extend their structural service life, or alternatively, be replaced. The Navy chose to extend the F-18 production line and is buying some additional F-18E/Fs while waiting for its F-35s. F-18E/F has tremendous capabilities, but is still less than a fifth-generation fighter. It is a plan that the Air Force could consider as well. While the Air Force has not bought any new F-15s or F-16s for more than 20 years, allies are currently procuring new F-15s and F-16s, so the production lines are open; these jets have integrated advanced capabilities which could be further enhanced for US use. The debate of whether advanced fourth-generation aircraft are enough to meet national security requirements or does America really need fifth-generation fighters is alive and well, and the discussion continues as F-35 costs continue to grow and production deliveries move farther into the future. Buying more fourth-generation fighters which are significantly less expensive certainly augments the quantity of airplanes and the capacity to confront future adversaries, but the capability to win decisively and quickly is also less, so determining the threat level is paramount to making that type of decision.

A final future risk is whether the F-35, suffering similar programmatic delays and cost overruns as F-22, will survive politically. The general consensus is it will, but the quantities may eventually be reduced. The fact that some international partners paid into the development and that foreign military sales will reduce US production costs while bolstering capabilities of allies are significant bargaining chips that F-35 backers

hold with Congress and DoD that F-22 did not have. Ultimately, this diminishes the risk of the F-35 program being terminated, which would cause entirely different issues.

Ramifications of a New Strategy and National Budget Challenges

Turning from an assessment of the magnitude of the various risks postulated to have been accepted in 2010, as a result of new strategic guidance, the Air Force and DoD may have incurred additional risk by cancelling F-22 early. In January 2012, the Secretary of Defense released "Sustaining U.S. Global Leadership: Priorities for 21st Century Defense," which reflects a change in strategy from the primary focus to being on fighting today's wars to also include preparing the Joint Force for future challenges.[80] The strategy identifies a geopolitical environment shift to emphasize the Asia-Pacific theater as well as the Middle East.[81] Finally, it is founded under the premise DoD budget's will continue to decline and includes the planned reduction of the budget by $487 billion over the next ten years. In his press conference to release the guidance, Secretary of Defense Leon Panetta explicitly stated that the new strategy does not include the impacts of sequestration if it were to occur in January 2013, resulting in an additional $500 billion to be taken from the defense budget during that ten-year period.[82]

General Martin Dempsey, Chairman of the Joint Chiefs of Staff, announced that the risks in the new strategy would be measured in "time and capacity."[83] The strategy emphasizes Asia first, which means that the Air Force and the Navy will play larger roles in the strategic planning with longer range assets. F-22 is more suited for that environment, but fewer F-22s is a risk in time and capacity in that it could hamper the ability to rapidly achieve air dominance with a near-peer or in a less permissive, anti-access environment. The need for longer range stealth assets also points to the reason

DoD is pursuing a new long range strike bomber to be fielded in the 2020s. There are many important priorities which need to be funded to address the emerging strategy.

As the defense budget declines, the developmental, flyway, and overall program costs of F-35 continue to grow, and the F-35 faces similar developmental and fielding delays as F-22 did, the 2010 decision to halt F-22 production early may have been suboptimal. In the most recent budget, DoD reallocated over $15 billion from the entire F-35 program between FY13-17 and deferred (but did not cancel) production deliveries to reduce concurrency in the program and try to stave off pitfalls encountered by F-22. At this point, flyaway costs for F-35 for FY11 are approximately $121 million, well above the originally advertised flyaway cost of about $65 million and approaching F-22's final flyaway cost.[84] Right now, F-35's planned development and procurement program is $382 billion, not including operations and sustainment costs which are anticipated to top $1 trillion over F-35's life cycle.[85] This is a tremendous bill to pay for our security.

Based on the new strategy and applying the QDR risk framework to the F-22 cancellation, the overall risks are somewhat altered. The operational risk is probably the same because the threat of the anti-access environment is mostly in the Asia-Pacific theater. The force management risk is medium for airplanes, given the need to acquire a new tanker, F-35, and a new bomber as well as other critical intelligence, surveillance, and reconnaissance and space assets, and low for the personnel needs because of the same overall Air Force culture. Institutional risk is well past for F-22, but is probably medium to high for F-35 and other programs facing acquisition process challenges. There will be less tolerance in a declining budget environment for acquisition delays and overruns and perhaps more willingness to look at other less capable but more

affordable options. The defense industrial base will also have higher risk, not because of F-22's cancellation but because of a lack of new programs for the aerospace industry overall in the 2020s and the potential inability of industry to attract and retain technical expertise. The future challenges risk is the same assuming F-22, F-35, tanker, and the new bomber are all successfully fielded in reasonable inventory numbers, otherwise it is higher than it currently is. The risk of all the systems being available to meet these challenges grows with every F-35 delay and cost increase.

Conclusion

"Strategic risks are the risks that (a) the business model is not effectively aligned with the strategy or (b) one or more future events may invalidate fundamental assumptions underlying the strategy."[86] Risks are born from internal process issues and external disruptions, such as technology, economic changes, and competition. DoD operates in a realm where strategic risks are always prevalent; the goal is to align the force structure to the strategy in a way that provides the most flexibility to morph when the threats change. When DoD makes strategic decisions to meet the national security objectives, strategic risks are always present and mitigations must be put in place to reduce the potential likelihood and consequences of the risks coming to fruition.

The cancellation of F-22 production in 2010 was a strategic decision which came with operational, force structure, institutional, and future challenges risks. The program was cancelled for a myriad of reasons, including cost overruns in a tightening economy, changes in the geopolitical environment post-Cold War, sense of no peer competitor, large schedule delays, perception of poor acquisition performance, and political pressures. In the end, the program was deemed not affordable, so the Air Force and

DoD must adjust strategy accordingly to ensure the 187 aircraft which were procured will be sufficient to address national security needs.

To assess the quality of a decision, Stanford University's Strategic Decision and Risk Management Program advocates six elements to evaluate: appropriate frame; creative, doable alternatives; meaningful, reliable information; clear values and tradeoffs; logically correct reasoning; and commitment to action.[87] Using these criteria, the decision to cancel F-22 fulfilled these elements and was a reasonable decision, made with a realistic understanding of the assumed risks. Was it the best possible decision? That is certainly debatable, particularly whether the 187 F-22s are sufficient to fulfill the needs of multiple combatant commanders simultaneously. At the time, it was probably necessary for the decision to be forced on the Air Force because the Air Force was so culturally tied to F-22 that it corporately had difficulty articulating other reasonable options, yet needed to increase investments in other capability areas.

Given the new security strategy and the extreme budgetary pressures, it appears that operational risk in particular was underestimated in the 2010 QDR F-22 decision process. Today's Asia-Pacific first emphasis, costs of sustaining and modernizing legacy aircraft, capacity concerns to meet multiple high threat taskings simultaneously, and delays in fielding F-35 contribute to elevating the risk incurred by truncating F-22 early. The possibility of sequestration taking effect in January 2013, removing an additional $500 billion from the defense budget over the next 10 years, would cause DoD to "shed missions, commitments, and capabilities necessary to protect core U.S. national security interests, resulting in a demoralized and hollow force."[88] It would

require a revamp of the new strategy, and would put tremendous pressure on acquiring a complementary mix of forces to ensure security around the world.

America is willing to spend a great deal of money on defense to ensure national security. However, "the Department and the nation can no longer afford the quixotic pursuit of high-tech perfection that incurs unacceptable cost and risk."[89] Our defense strategies depend on air dominance being established quickly and assume meeting that objective is a given, but in the future it may not be if we do not invest in the right mix of platforms and weapons to defeat adversary threats. Although the F-22 is an expensive aircraft to operate, its capabilities are worth the costs to ensure preparedness for rising threats. But it is also true that the country cannot afford infinite capability, and that balanced risks must be taken. The challenge is to find where strategy and capability intersect, and to resource efforts accordingly to best position the nation for success. "We must be prepared to make hard decisions about the trade-off between performance and price in our capabilities, while recognizing that a push for "one-size-fits all" solutions may result in a greater risk of reduced flexibility during operations."[90]

Endnotes

[1] Robert M. Gates, *Quadrennial Defense Review* online (Washington, DC: U.S. Department of Defense, February 2010), v, http://www.defense.gov/qdr, (accessed October 4, 2011).

[2] U.S. Department of Defense, "About the Department of Defense (DoD)," http://www.defense.gov/about/ (accessed January 16, 2012).

[3] Gates, *QDR*, v.

[4] "Defence Budgets Military Ranking," *The Economist Online*, March 9, 2011, http://www.economist.com/blogs/dailychart/2011/03/defence_budgets (accessed January 16, 2012). This article cites its source as the International Institute for Strategic Studies. The $693 billion also includes supplemental funds for Overseas Contingency Operations (OCO) in

addition to the base budget. China is the number two country in defense spending as cited in this report at $76 billion, well below the United States.

[5] ADM Michael G. Mullen, *National Military Strategy* online (Washington, DC: The Joint Staff, February 2011), http://www.jcs.mil/content/files/2011-02/020811084800_2011_NMS_-_08_FEB_2011.pdf, 4 (accessed October 30, 2011).

[6] Gates, *QDR*, xi.

[7] Office of the Undersecretary of Defense (Comptroller), *Fiscal Year 2013 Budget Request (*February 2012), 4, http://comptroller.defense.gov/budget.html (accessed February 13, 2012).

[8] U.S. Department of the Air Force, *Air Force Basic Doctrine, Organization, and Command, Air Force Doctrine Document 1* (Washington, DC: United States Air Force, October 14, 2011), 43.

[9] Mackenzie Eaglen, "USA's 56-Year Air Superiority At Risk," *The Foundry Online,* June 25, 2009, http://blog.heritage.org/2009/06/25/usas-56-year-air-superiority-at-risk/ (accessed February 15, 2012).

[10] U.S. Department of the Air Force, "U.S. Air Force Fact Sheet: F-15 Eagle," October 22, 2009, http://www.af.mil/information/factsheets/factsheet.asp?fsID=101 (accessed February 15, 2012).

[11] Rebecca Grant, *"Losing Air Dominance,"* (Washington DC: Mitchell Institute for Airpower Studies, September 2008), 7, http://www.afa.org/mitchell/reports/0908air_dominance.pdf (accessed February 18, 2012).

[12] U.S. Department of the Air Force, "U.S. Air Force Fact Sheet: F-22 Raptor," November 25, 2009, http://www.af.mil/information/factsheets/factsheet_print.asp?fsID=199&page=1 (accessed December 18, 2011).

[13] Ibid.

[14] Ibid.

[15] In my last Air Force job, I was the squadron commander and Materiel Leader for the Small Diameter Bomb (SDB) I program (July 2008-June 2011) and SDB I was undergoing testing to be integrated on F-22 during this timeframe. The F-22 fleet was operating with restrictions beginning in January 2011 due to concerns with the oxygen supply system. SDB I completed its operational testing with F-22 in March 2011, but that effort was just a portion of the capability being added to the jet in Increment 3.1. Fielding of the software and new capabilities were delayed when the entire F-22 fleet was placed on stand down from May to September 2011 due to confirmed issues with the oxygen system (see also Air Force Association Daily Report, "Air Frame," September 26, 2011, http://www.airforce-magazine.com/DRArchive/Pages/default.aspx (accessed September 28, 2011). There were approximately four months of operational testing remaining prior to the stand down, so with the time to get the pilot force current again, resume and finish testing, and complete the reporting and approval cycle favorably, I estimate the Increment 3.1 upgrade should field during 2012.

[16] Jonathan Doelp, Headquarters Air Force Combat Air Forces Requirements, "Point Paper on F-22 Requirements History," Washington DC, February 3, 2009.

[17] One such classified study was "Sustaining Air Dominance" in 2002.

[18] U.S. Department of Defense, "Program Budget Decision 753: Other Secretary of Defense Decisions," Washington, DC, December 23, 2004, 9 and 19.

[19] Gates, *QDR*, 40; and U.S. Department of the Air Force, *Fiscal Year 2011 Budget Estimates, Aircraft Procurement, Air Force Volume I* (February 2010), 1-15, http://www.saffm.hq.af.mil/shared/media/document/AFD-100128-072.pdf, (accessed December 14, 2011).

[20] USAF, *Fiscal Year 2011 Budget Estimates, Aircraft Procurement, Air Force Volume I*, 1-15.

[21] Senior Airman Danielle Purnell, "Lockheed-Martin rolls out final F-22 Raptor," *Official Website of the U.S. Air Force,* December 15, 2011, http://www.af.mil/news/story.asp?id=123283566 (accessed December 15, 2011).

[22] Air Force Association Daily Report, "End of the Line," December 14, 2011, http://www.airforce-magazine.com/DRArchive/Pages/default.aspx (accessed December 14, 2011). This paper refers to 187 as the inventory throughout because it was the approved quantity.

[23] Defense Acquisition University, "Cost Terms," *ACQuipedia*, https://acc.dau.mil/CommunityBrowser.aspx?id=243016 (accessed February 8, 2012).

[24] U.S. Department of the Air Force, *FY 2008/2009 Budget Estimates, Aircraft Procurement, Air Force Volume I* (February 2007), 1-13, http://www.saffm.hq.af.mil/shared/media/document/AFD-070212-004.pdf; U.S. Department of the Air Force, *FY 2010 Budget Estimates, Aircraft Procurement, Air Force Volume I* (May 2009), 1-15, http://www.saffm.hq.af.mil/shared/media/document/AFD-090511-090.pdf; USAF, *Fiscal Year 2011 Budget Estimates, Aircraft Procurement, Air Force Volume I*, 1-15; and U.S. Department of the Air Force, *United States Air Force Fiscal Year 2012 Budget Estimates, Aircraft Procurement, Air Force Volume I* (February 2011), 1-25, http://www.saffm.hq.af.mil/shared/media/document/AFD-110211-038.pdf (all accessed December 14, 2011).

[25] USAF, "U.S. Air Force Fact Sheet: F-15 Eagle;" and U.S. Department of the Air Force, "U.S. Air Force Fact Sheet; F-16 Fighting Falcon," October 30, 2009, http://www.af.mil/information/factsheets/factsheet.asp?fsID=103 (accessed February 20, 2012). Flyaway costs for F-15C and F-16C in FY1998 dollars were manually inflated to FY2010 dollars for approximate comparison with F-22.

[26] USAF, *United States Air Force Fiscal Year 2012 Budget Estimates, Aircraft Procurement, Air Force Volume I*, 1-25. Full program costs come from looking at the past R-Docs and the P-Docs.

[27] Ibid., 1-1 and 1-25. Full program costs come from looking at the R-Docs and the P-Docs and estimation.

[28] August Cole and Yochi J. Dreazden, "Pentagon Pushes Weapons Cuts," *The Wall Street Journal Online*, April 9, 2007, http://online.wsj.com/article/SB123903026250593091.html (accessed February 14, 2012).

[29] Protiviti, Inc., "Performance/Risk Integration Management Model – PRIM^2: Early Mover Series – Analyzing Strategic Risk," August 1, 2011, http://www.knowledgeleader.com/KnowledgeLeader/Content.nsf/Web+Content/ARTPerformanceRiskIntegrationManagementModelPRIM2EarlyMoverSeriesAnalyzingStrategicRisk!OpenDocument (accessed January 18, 2012).

[30] Gates, *QDR*, 90.

[31] Ibid., vi.

[32] Tom McIntyre, Headquarters Air Combat Command F-22 Requirements Office, "Background Paper on USAF F-22 Requirements," Langley Air Force Base, Virginia, November 24, 2008. For clarification, DoD planning guidance at the time came in the form of the Strategic Planning Guidance and the Joint Planning Guidance; those two documents are now part of the singular Defense Planning Guidance document.

[33] Ibid. Also, historically the number of combat coded fighter aircraft is between 60 and 75 percent of the total inventory for each airframe.

[34] Ibid.

[35] Ibid.

[36] Lt Col Craig "Bluto" Baker, U.S. Air Force, interview by author, Carlisle Barracks, PA, January 30, 2012. Bluto was most recently an F-22 squadron commander and previously served at Headquarters Air Force, Combat Air Forces Requirements, where part of his portfolio was the F-35A.

[37] USAF, "U.S. Air Force Fact Sheet: F-15 Eagle."

[38] David A. Fulghum, "Upgraded F-15Cs to protect F-22s," *Aviation Week online*, April 14, 2010, http://www.aviationweek.com/aw/blogs/defense/index.jsp?plckController=Blog&plckBlogPage=BlogViewPost&newspaperUserId=27ec4a53-dcc8-42d0-bd3a-01329aef79a7&plckPostId= Blog%3a27ec4a53-dcc8-42d0-bd3a-01329aef79a7Post%3a39df4196-72dd-4601-b2ec-7784bff0ffc6&plckScript=blogScript&plckElementId=blogDest (accessed February 16, 2012).

[39] Studying the last six to seven years of Air Force budget documentation shows a myriad of upgrades planned and implemented for the F-15 fleet, particularly the C/D/E models.

[40] Fulghum, "Upgraded F-15Cs."

[41] James Dobbins et al, "Conflict with China: Prospects, Consequences, and Strategies for Deterrence," (Santa Monica: RAND Corporation, 2011), 11, http://www.rand.org/content/dam/rand/pubs/occasional_papers/2011/RAND_OP344.pdf (accessed February 17, 2012).

[42] Gates, *QDR*, 90.

[43] U.S. Department of the Air Force, "Air Force Recruiting Service," February 7, 2012, http://www.rs.af.mil/library/factsheets/factsheet.asp?id=6809 (accessed February 10, 2012).

[44] Carl H. Builder, *The Masks of War: American Military Styles in Strategy and Analysis* (Baltimore: The Johns Hopkins University Press, 1989), 19-23.

[45] **"**Air Force meets recruiting goals for tenth year in a row," October 13, 2009, http://www.af.mil/news/story.asp?id=123172437; "2010 Proves Banner Year for Recruiting," October 10, 2010, http://www.defense.gov/News/NewsArticle.aspx?ID=61244; and "DoD Announces Recruiting and Retention Numbers for Fiscal 2011," October 20, 2011, http://www.defense.gov/releases/release.aspx?releaseid=14871 (all accessed February 10, 2012).

[46] Amy McCullough, "Too Much of a Good Thing," *Air Force Magazine* online, Vol 94, No.9, September 2011, http://www.airforce-magazine.com/MagazineArchive/Pages/2011/September%202011/0911thing.aspx (accessed February 10, 2012); and Michael Donley and Norton Schwartz, "Air Force Priorities for a New Strategy with Constrained Budgets," 3, http://www.af.mil/news/story.asp?id=123288229 (accessed February 2, 2012).

[47] "ACC Chief Sees Smaller Yet Capable Future Air Force," *Defense Daily online*, Vol. 222, Issue 60, June 25, 2004, http://proquest.umi.com.ezproxy.usawcpubs.org/pqdlink?vinst=PROD&fmt=3&startpage=-1&vname=PQD&RQT=309&did=655398471&scaling=FULL&vtype=PQD&rqt=309&TS=1323742517&clientId=20167 (accessed December 12, 2011).

[48] With the consolidation of F-22 operating locations, the squadron PAA size varies which complicates planning, manning, and sustainment.

[49] Baker, interview.

[50] Ibid.

[51] Ibid. "Experienced" implies 7-level qualifications, which take an average of 12 or more years to obtain in an Air Force enlisted career field.

[52] Ibid.

[53] Gates, *QDR*, 90.

[54] Ibid., iii.

[55] Ibid., 76.

[56] David W. Barno, Nora Bensahel, and Travis Sharp, "Hard Choices: Responsible Defense in an Age of Austerity," Center for a New American Security, October 2011, 11, http://www.cnas.org/hardchoices (accessed November 10, 2011).

[57] Gates, *QDR*, 93.

[58] Dr. Mark A. Lorell, Senior Political Scientist, RAND Corporation, telephone interview with author, January 19, 2012. Dr. Lorell performs extensive research work in defense cooperation, military acquisition and procurement, the defense industrial base, and military technology.

[59] Dawn Vehmeier, "Industrial Base Considerations in the QDR: Overview of Industrial Policy Participation," December 3, 2009, 5, http://www.acq.osd.mil/mibp/docs/presentations/Industrial_Base_Considerations_in_the_QDR_Dec%202009_DMC.pdf (accessed January 20, 2012).

[60] Jeremiah Gertler, "Air Force F-22 Fighter Program: Background and Issues for Congress," Congressional Research Service, December 22, 2009, 6, http://www.au.af.mil/au/awc/awcgate/crs/rl31673.pdf (accessed February 19, 2012).

[61] Mackenzie Eaglen and Eric Sayers, "Maintaining the Superiority of America's Defense Industrial Base," The Heritage Foundation May 22, 2009, http://www.heritage.org/Research/Reports/2009/05/Maintaining-the-Superiority-of-Americas-Defense-Industrial-Base (accessed November 9, 2011).

[62] USAF, *Fiscal Year 2011 Budget Estimates APAF Volume I,* 1-15.

[63] John C. Graser et al, "Retaining F-22 Tooling: Options and Costs," (Santa Monica: RAND Corporation, 2011), 15, http://www.rand.org/content/dam/rand/pubs/technical_reports/2011/RAND_TR831.pdf (accessed February 19, 2012).

[64] Ibid., xv.

[65] Ibid.

[66] Gates, *QDR*, 81, 83, 94; and Leon E. Panetta, *Sustaining U.S. Global Leadership: Priorities for 21st Century Defense* online (Washington, DC: U.S. Department of Defense, January 2012), www.defense.gov/news/Defense_Strategic_Guidance.pdf, 8 (accessed January 13, 2012).

[67] Office of Under Secretary of Defense Acquisition, Technology & Logistics, Office of Manufacturing & Industrial Base Policy, "DoD Annual Industrial Capabilities Report to Congress," September 2011, 1, http://www.acq.osd.mil/mibp/docs/annual_ind_cap_rpt_to_congress-2011.pdf (accessed November 18, 2011).

[68] John Birkler et al, "Keeping a Competitive U.S. Military Aircraft Industry Aloft: Findings from an Analysis of the Industrial Base," (Santa Monica: RAND Corporation, 2011), http://www.rand.org/pubs/monographs/MG1133.html (accessed January 20, 2012). This entire report provides an outstanding overview and assessment of how the aerospace defense industrial base could be sustained with the influx of new programs.

[69] Gates, *QDR*, 90.

[70] McIntyre, "F-22 Requirements."

[71] USAF, *United States Air Force Fiscal Year 2012 Budget Estimates, Aircraft Procurement, Air Force Volume I*, 1-1; and U.S. Department of the Navy, *Department of the Navy Fiscal Year*

2012 Budget Estimates, Aircraft Procurement, Navy, Volume I, Budget Activities 1-4 (February 2011), 57, http://www.finance.hq.navy.mil/FMB/12pres/APN.HTM (accessed February 20, 2012).

[72] "F-35A IOC Slip Confirmed," *Air Force Magazine online,* April 20, 2011 http://www.airforce-magazine.com/DRArchive/Pages/2011/April%202011/April%2022%202011/F-35AIOCSlipConfirmed.aspx (accessed February 20, 2012).

[73] "Largest Lockheed Martin F-35 Fleet Now Resides at Eglin Air Force Base," January 19, 2012, http://www.lockheedmartin.com/us/news/press-releases/2012/january/120119ae_f-35-fleet-now-resides-eglin.html (accessed February 20, 2012).

[74] Air Force Association, "Air Dominance The Key to Success for the Joint Force in the 21st Century: F-22 Raptor and F-35 Lightning II," 2009, 13, http://www.afa.org/grl/PDFs/F-22--JSF_Brief_09.pdf (accessed February 18, 2012).

[75] Baker, interview.

[76] J.R. Wilson, "Anti-Access Air Defenses," *The Year in Defense: 2010 in Review* (Winter 2011): 87.

[77] Ibid.

[78] Eaglen and Sayers, "Maintaining the Superiority of America's Defense Industrial Base."

[79] U.S. Department of the Air Force, *United States Air Force Fiscal Year 2012 Budget Estimates, Aircraft Procurement, Air Force Volume II* (February 2011), 5-157 http://www.saffm.hq.af.mil/shared/media/document/AFD-110211-039.pdf (accessed December 14, 2011).

[80] Panetta, *Sustaining U.S. Global Leadership, 1*.

[81] Ibid., 2.

[82] Barack H. Obama, Leon E. Panetta, and Martin E. Dempsey, "Defense Strategic Guidance Briefing from the Pentagon," Washington DC, January 5, 2012, http://www.defense.gov/transcripts/transcript.aspx?transcriptid=4953 (accessed January 12, 2012).

[83] Ibid.

[84] USAF, *United States Air Force Fiscal Year 2012 Budget Estimates, Aircraft Procurement, Air Force Volume I*, 1-1. F-35 flyaway cost should decrease as production learning curves are established and Foreign Military Sales quantities are factored into production unless quantities drop significantly for economies of scale, processes do not gain efficiencies, or materiel costs increase substantially. It would be surprising if F-35 can get its flyaway cost as low as $65 million per aircraft, but in the end it should not be as high as $121 million across the 1763 (or how many ever are procured) aircraft. Regardless, the longer development takes, the program acquisition cost (cost per airplane including RDT&E, procurement, and MILCON) will continue to grow.

[85] Greg Grant, "JSF Price Tag Now $112 Million Per Plane; Program $382 Billion," June 1, 2010, http://www.dodbuzz.com/2010/06/01/jsf-price-tag-now-112-million-per-plane/#ixzz1mDmfWUCE (accessed February 12, 2012). Also, growth can be seen by tracing the budget numbers in the Budget Documentation for Research, Development, Test & Evaluation and Procurement.

[86] Protiviti, Inc., "Performance/Risk Integration Management Model – PRIM^2."

[87] Stanford University Strategic Decision and Risk Management, "Decision Quality: The Art and Science of Good Decision-Making," webinar and briefing slides, October 19, 2011, 9, http://strategicdecisions.stanford.edu/ (accessed October 19, 2011).

[88] Obama, Panetta, and Dempsey, "Defense Strategic Guidance Briefing from the Pentagon."

[89] Gates, *QDR*, 76.

[90] "Part II: Trends Influencing the World's Security," *The Joint Operating Environment 2010,* (Norfolk VA: U.S. Joint Forces Command, February 2010), 22.